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[Title of the Invention] LIGHT-EMITTING DEVICE DRIVING UNIT

[Claims for the Patent]

[Claim 1]

A light-emitting device driving unit characterized by being provided with a light-emitting device driving circuit in association with a plurality of light-emitting devices, said light-emitting device driving circuit comprising:

an output circuit for supplying power to the light-emitting device;

a pulse signal generation circuit for successively generating pulse signals; and

a pulse signal selection circuit including a shift register and a gate circuit for gating said pulse signals according to the output signal of said shift register, and adapted to supply said pulse signals to said output circuit as driving signals in response to the generation timing of said pulse signals,

wherein said pulse signals are selectively gated according to the data stored in said register so that the amount of light-emission is adjusted by the sum of the pulse widths of the selected pulse signals among said plurality of light-emitting devices.

[Claim 2]

The light-emitting device driving unit according to claim 1, characterized in that said shift register is a ring-shape register of which input and output sides are connected, and said pulse signal generation circuit successively generates pulse signals with different pulse widths.

[Claim 3]

The light-emitting device driving unit according to claim 2, characterized in that said plurality of light-emitting devices are an LED array used in a LED printer, and said pulses with different pulse widths are pulses of which widths successively decrease.

[Claim 4]

The light-emitting device driving unit according to any of claims 1 to 3, said pulse signal selection circuit is inputted with the output of a latch circuit for latching pixel data outputted from other shift registers, and sends out driving signals to the output circuit under the condition of logical multiplication between said inputted signal and the output signal of the gate circuit

[Detailed Description of the Invention]

[Industrial Application Field]

The present invention relates to a light-emitting device driving unit and specifically relates to such a light-emitting device driving unit as one capable of compensating the variation of the luminous intensity of a LED array for use in a LED printer by correcting the amount of light-emission thereof.

[Conventional Art]

In recent years, optical printers have gained attention as the printer which has potential to realize miniaturization, weight reduction, and speedups; these printers are configured such that a plurality of light-emitting device arrays, each of which integrates the monolithic of about 64 to 256 light-emitting devices such as a LED into a single chip, are arranged in a straight line across the width of the recoding paper.

The light source of a optical printer is required that the amount of light-emission is approximately uniform for all the light-emitting devices since it affects the printing speed, the diameter of dots, and the like; however, light-emitting devices such as LED arrays involve the variations in performance between individual devices due to the difference in production lot, the non-uniformity in the production process, and other factors. Therefore, various methods for compensating such variations have been proposed.

[Problems to be Solved]

The method which has been contemplated for compensating variations in luminance between devices in a LED array includes:

i) providing resistors of different resistance values in series in each device and driving the device at a constant voltage, and ii) controlling the current-conduction period for each device by using software or a ROM so that light exposure is uniform on the photosensitive body.

In these methods, since the luminance is adjusted for each single dot, the former case suffers disadvantages such as the difficulty in selecting resistance values corresponding to each dot and increased complexity of the production process. Therefore, the latter method of controlling the current-conduction time is commonly adopted; however, in that case, using software suffers a drawback of a reduced control speed, and using a ROM and the like also suffers a drawback in that since correction data for each single dot are to be pre-stored in a ROM and the current-conduction time is controlled by outputting them into latch stages as many as the number of information, reading out the current-conduction times from the ROM and sending out them are time consuming. Further, a ROM with a large capacity is needed as well as peripheral circuits such as timing control and comparator circuits thereby complicating the circuit configuration. The object of the present invention is to solve such problems of conventional art and to provide a light-emitting device driving unit which enables a high speed correction of the variation in the luminance among the light-emitting devices such as a LED array used in a LED printer while driving the LED.

[Means for Solving the Problem]

In order to achieve the above described object, the light-emitting device driving unit of the present invention is configured by being provided with a light-emitting device driving circuit in association with a plurality of light-emitting devices, said light-emitting device driving circuit comprising: an output circuit for supplying power to the light-emitting device; a pulse signal generation circuit for successively generating pulse signals; and a pulse signal selection circuit including a shift register and a gate circuit for gating said pulse signals

according to the output signal of said shift register, and adapted to supply said pulse signals to said output circuit as driving signals in response to the generation timing of said pulse signals, wherein said pulse signals are selectively gated according to the data stored in said register so that the amount of light-emission is adjusted by the sum of the pulse widths of the selected pulse signals among said plurality of light-emitting devices.

[Function]

As so far described, a pulse signal selection circuit having a shift register is provided before the output circuit for supplying power to the light-emitting devices so that the pulse signals from the pulse signal generation circuit is selected according to the shift data output of the shift register, and the driving signal of the output circuit is generated by combining the pulse widths of selected pulse signals to set the driving time of the light-emitting device; thus it has been achieved to readily determine the current-conduction time of the light-emitting device by combining the pulse widths according to the data of the shift register. As the result, it has been achieved to select different current-conduction times depending on the combination of the data to be stored in the shift register, and to adjust the amount of light-emission between the light-emitting devices by selectively setting the current-conduction time among them depending on the variation in the light-emitting performance of the devices. Therefore, the amount of light-emission can be readily adjusted to be uniform between each light-emitting device, and since that can be done simply by selecting the pulse signals, the correction can be performed in response to the timing of LED driving.

[Embodiments]

Embodiments of the present invention will be described in detail below referring to the drawings.

Fig. 1 is a block diagram of an embodiment of the light-emitting device driving unit according to the present invention; Fig. 2 is a block diagram of another embodiment; and

Fig. 3 is a timing chart to illustrate the operation of the embodiments.

In Fig. 1, LED light-emitting part 1 consists of LED arrays 1a, 1b, ..., 1n; each LED 10 in the arrays is driven by a driving power signal from current amplification circuits 2a, 2b, ..., 2n of the output circuit part 2; and each individual LED 10 emits light respectively.

The current amplification circuits 2a, 2b, ..., 2n of the output circuit part 2 comprise LED driving circuits 20 which are provided corresponding to each LED 10 of the LED arrays 1a, 1b, ..., 1n, and each of these LED driving circuits 20 drives corresponding LEDs 10.

The pulse signal selection circuit part 4 consists of pulse signal selection circuits 4a, 4b, ..., 4n and receives a plurality of strobe signals having different pulse widths from the pulse signal generation circuit 5. Each pulse signal selection circuit 4a, 4b, ...,4n has a strobe signal selection circuit provided corresponding to each LED driving circuit 20 respectively, and the strobe signal selection circuit consists of a shift register 41 and a gate circuit 42. And, the gate circuits 42 serially receive a plurality of strobe signals having different pulse widths from the pulse signal generation circuit 5, and send driving signals to each LED driving circuit 20 obtained based on the logical multiplication among the strobe signal and data of each stage stored in the shift register 41, and a latch data output signal of the data latch circuit described below. Here, the shift register 41 is a memory to store data of multiple bits, and the data are sent out from ROM 6 to the shift register 41 of each strobe signal selection circuit of the pulse signal selection circuit 4a, 4b, ..., 4n, and are set and shifted in response to the shift signal S generated corresponding to each strobe signal from the pulse signal generation circuit 5 to be outputted.

7 denotes a data latch circuit part, which consists of data latch circuits 7a, 7b, ..., 7n, and latches and stores pixel data bit by bit obtained from each shift register 8a, 8b, ...,

8n of the shift register circuit part 8 corresponding to each LED 10.

The output signal of each data latch output Q1, Q2, ..., Qn of the data latch circuit 7a, 7b, ..., 7n is sent out as the output corresponding to the latch data to the gate circuit 42 of each strobe signal selection circuit.

The pulse generation circuit 5 is configured to sequentially generate n serial number of strobe signals 51a, 51b, 51c, ...51n having successively reducing pulse widths (W1>W2>W3>...>Wn), and some of these strobe signals are selected to generate a driving signal based on the sum of the pulse widths, and thereby the current conduction of LED 10 is controlled to correct the luminance variation thereof.

Moreover, the first strobe signal 51a of these strobe signals may be selected to be the pulse width as a basic strobe pulse. This is a reference pulse, of which pulse width has a period set corresponding to a minimum light-emitting time for a LED of an approximately maximum luminance in the variation of LEDs 10, and is added uniformly to all the LEDs 10. In such a case, the strobe signals 51b, 51c, ..., 51n, which are pulse signals following the strobe signal 51a, become a correction strobe pulse respectively; these pulse widths are in a decreasing order; and the time obtained from the sum of the pulse width of the strobe signal 51a and the pulse widths of the pulse signals selected from the corrected strobe signals 51b, 51c, ..., 51n provides a total light-emitting time of the LED 10.

Further, the total period obtained as the sum of all the pulse widths of the pulse signal generation circuit 5 provides the period set to be the maximum light-emitting time corresponding to a LED of approximately minimum luminance in the luminance variation of LEDs 10.

In such a circuit, it is assumed that when the data are stored in the shift register 41, for example, in a positive logic operation, the number of pulses successively generated at a time by the pulse signal generation circuit 5 is 5; the shift register 41 consists of 5 stages of flip-flops; and bits "11101" are stored

in each stage of the shift register 41.

In such condition, when the pixel data of the latch circuit is "1", the first to third strobe signals and the fifth strobe signal are picked up out from each strobe signal generated by the pulse generation circuit 5, in response to the shift signal S from the pulse signal generation circuit 5 which is added to the shift register 41; and thus the fourth strobe signal drops off.

That is, since these first thee strobe signals 51a, 51b, 51c and the last strobe signal are subjected to a logical multiplication operation corresponding to each digit of the data "11101" stored in the shift register 41, and this result is also subjected to a logical multiplication operation with the latch output signal of the data latch circuit; those strobe signals of the pulse signal generation circuit 5, which are generated corresponding to the digit set to "1" in the data of the shift register 41 in response to the shift signal S, are selectively picked up; and a driving signal of total time of the pulse widths can be generated as the total of the driving signals generated separately corresponding to the strobe signal. Thus, this enables to control the current-conduction time of the LEDs 10.

Further, the shift signal S which is added at that moment may be generated separately, and in such a case, may be generated in synchronization with the generation timing of the pulse signals of the pulse signal generation circuit 5. Furthermore, the shift register 41 can circulate those data using a ring-shape register, of which input and output sides are connected, returning them into an original state. Also, the data to be set in the shift register 41 are inputted from ROM 6 into so called a LED head, which includes this light-emitting device driving circuit and the LED light-emitting part, at the initial time in driving the LED head. Such an embodiment is shown in Fig. 2.

In Fig. 2, 11 denotes a pulse signal selection circuit; and 12 denotes an output circuit part having LED driving circuits 12a, 12a, ... consisting of FET transistors in correspondence

to each LED 10, and corresponds to the output circuit 2 of Fig. 1. Also, 13 is the latch circuit corresponding to the data latch circuit part 7, and has latch circuits 13a, 13b, ... corresponding to the gate circuits 14, 14, ... of the pulse signal selection circuit.

The gate circuit 14 is a three-input gate circuit and corresponds to the gate circuit 41 of Fig. 1; and the shift register 15 corresponds to the register 42. Each shift register 15 is a n-stage shift register consisting of flip-flops (FF) 15a, ... 15_{n-1}, 15_n; and its input and output sides are connected thereby forming a ring-shape register. Furthermore, for each shift register 15, flip-flops in each stage: i.e. flip-flops 15a, 15a, ..., flip-flops 15_{n-1}, 15_{n-1}, ..., and flip-flops 15n, 15n ... are connected respectively in the lateral direction via a buffer thus forming a shift register in the lateral direction.

And, such gate circuits 14, 14, ... and shift registers 15, 15, ...constitute the pulse signal selection circuit 11. Further, 16 is the circuit corresponding to the shift register part 8 of Fig. 1, and has registers of each stage for storing each pixel data 16a, 16a, ... provided corresponding to each LED 10.

Moreover, the diode circuit 12c, 12c, ..inserted into the output of the LED driving circuit 12a, 12a, ..through the FET transistors of the output circuit part 12 is inserted as an input protection circuit. Further, logic circuits 12b, 12b, ..inserted in series on the input side are logic circuits for adjusting the luminance of whole LEDs by uniformly setting the LED driving current value to control the gate voltage of each LED driving circuit 12a. This indicates that if the output of the gate circuit 14 is "1" (or HIGH level, hereinafter simply referred to as "H"), the voltage of the CTL signal is applied to the gate terminal of the FET transistor constituting the LED driving circuit 12a, turning it "ON" and the current set by the voltage of the CTL signal is supplied to the LED 10. On the other hand, the output of the gate circuit 14 is "0" (or LOW level, hereinafter simply referred to as "L"), the voltage of

the CTL signal is shut off, and the FET transistor of the LED driving circuit 12a becomes "OFF" state.

BY the way, setting of strobe signal selection data of the shift register 15 is performed by adding thereto clock pulse signal OC 17 (see the bottom part of the figure) from the oscillation circuit (not shown) as the clock signal and shift signal of each flip-flop 15a, ... 15_{n-1}, 15_n as the complementary signals for the outputs passed and not passed through an inverter.

Also, ST is, as seen as ST in Fig. 3, a strobe signal to be inputted to each of the gate circuit 14, 14, ...and is supplied form the pulse generation circuit 5; and corresponds to the strobe signals 51a, 51b, 51c, ..in Fig. 1. LA is a latch signal and is a timing signal for receiving data corresponding to pixels from each register 16a of the shift register 16 to latch them, and is inputted to each latch circuit 15 via the buffer 18a. DI is the signal of pixel data and is successively inputted to each register 16a of the shift register 16 via the buffer 18b. CK is a shift clock signal for the shift register 16, and is inputted to the register 16a via the inverter 18c.

CD_1I to CD_{n-1}, CD_n are signals for inputting data for strobe signal selection via the buffer 18d, 18d, ..into flip-flops in each stage of the first shift register shown in the left part of the drawing, and are signals to be sent out from ROM 6. CCK is a clock signal in this respect, and is supplied to each flip-flop via inverter 30 and buffer 31. Further, each flip-flop 15a, ...15_{n-1}, 15_n, in which ST signal is subjected to a wired OR operation with buffer 31 via the buffer 32, sends this to each flip-flop as the shift signal. Accordingly, a shift register of the shift register 15 is generated in accordance with the generation timing of strobe signal of the ST signal.

Next, referring to Fig. 3, its overall operation will be described.

As can be seen in (a) of Fig. 3, when the OC signal turns to be "L" and a CCK signal is added, the shift register becomes a state in which data are to be inputted, and when CDI signals (CD_1I to CD_{n-1}, CD_n are represented by CDI) are sent out from

ROM 6, these are inputted into flip-flops 15a, ... 15_{n-1}, 15_n, thereby being successively shifted to flip-flops 15a, ... 15_{n-1}, 15_n of each of corresponding stages from the left side to the right side in the figure, and sequential data being written into flip-flops of each of laterally corresponding stages.

In this way, predetermined data are stored, from ROM 6, in each stage of each shift register 15, 15, ... at the time of initialization. When this step of storing data is finished, a clock pulse signal CK is generated, the register 16a of each stage of the shift register 16 shifts the inputs of pixel data DI from left to right in the figure in response to the clock pulse signal CK and store them as described above.

When storage of pixel data in each register 16a is finished, next, a LA signal is generated, and data in each register 16a are latched to each latch circuit 13a. Consequently, the signals of latched data are sent out to each gate circuit 14.

When OC signal is in a "H" state, if a ST signal, which is a strobe signal, is added in the above described state from the pulse signal generation circuit 5, data in the flip-flop of each stage of the shift register 15 are shifted at every pulse of this ST signal and are sent out to each gate circuit 14. At this point, since the ST signal is also added to each gate circuit 14, for those of which a logical multiplication condition holds, the pulses of the ST signal are outputted to each logic circuit 12b as the driving signal for each LED driving circuit 12a. As the result, each pulse of the ST signal is selected according to the data set in the flip-flops 15a, ...15_{n-1}, 15_n of each shift register 15.

When, as seen in Fig. 3, the pulse width of each pulse of the ST signal is configured to successively decrease, any pulse may be selected from these pulses with various pulse widths through the data to be set in each stage of the shift register 15, it being possible to set the total time of the driving signal.

Furthermore, since, in this embodiment, the flip-flop 15a and the flip-flop 15n are connected forming a ring shape, when shifting is performed n times, the stored data return to the

original state, there being no need of inputting them into the register 15 again once data are set at the initial point. In this way, various kinds of data for strobe signal selection can be set in the shift register and, by combining them, driving signals with various periods can be added to each LED driving circuit 12a.

By the way, V_{DD} in the output circuit part 12 is a signal to be added to the power supply terminal 3, and GND is a signal to represent the ground level. Moreover, FET transistors 12d, 12e are transistor circuits inserted for voltage stabilization.

In this embodiment, the average luminance of the LED can be adjusted by the CTL signal by inputting the CTL signal into the output circuit, and further the variation of the luminance can also be adjusted for each dot.

As so far described, the embodiments utilize a shift register, and the number of stages in the shift register may be freely specified provided that it is more than one. Moreover, the pulses generated from the pulse signal generation circuit are not limited to those of which widths successively decrease as shown above. Preferably, these pulses have different widths and pulses with the same width can also be used by combining several of them. Furthermore, in this embodiment, although a LED system is presented as an example, it is obvious that the invention is applicable to other light-emitting devices.

[Advantages of the Invention]

As will be understood from the above description, according to the present invention, a pulse signal selection circuit having a shift register is provided before the output circuit for supplying power to the light-emitting devices so that the pulse signals from the pulse signal generation circuit are selected according to the shift data output of the shift register, and the driving signal of the output circuit is generated by combining the pulse widths of selected pulse signals to set the driving time of the light-emitting device; thus it has been achieved to readily determine the current-conduction time of the light-emitting device by combining the pulse widths according

to the data of the shift register. As the result, it has been achieved to select different current-conduction times depending on the combination of the data to be stored in the shift register, and to adjust the amount of light-emission between the light-emitting devices by selectively setting the current-conduction time among them depending on the variation in the light-emitting performance of the device. Therefore, the amount of light-emission can be readily adjusted to be uniform between each light-emitting device, and since that can be done simply by selecting the pulse signals, the correction can be performed in response to the timing of LED driving.

[Brief Description of the Drawings]

Fig. 1 is a block diagram of an embodiment of the light-emitting device driving unit according to the present invention; Fig. 2 is a block diagram of another embodiment; and Fig. 3 is a timing chart to illustrate the operation of the embodiments.

[Description of Symbols]

1 LED light-emitting part;
1a, 1b, 1c, 1n LED array;
2, 12 Output circuit;
2a, 2b, 2c, 2n Current amplification circuit;
4 Pulse signal selection circuit part;
4a, 4b, 4c, 4n Pulse signal selection circuit;
5 Pulse signal generation circuit;
6 ROM;
7 Data latch circuit part;
7a, 7b, 7c, 7n Data latch circuit;
8 Shift register circuit part;
8a, 8b, 8c, 8n, 41, 15 Shift register;
13, 15, 17 Flip-flop;
12a, 20 LED driving circuit;
14, 42 Gate circuit;
ST Strobe signal.

Fig.1

#1	Pixel data input
#2	Clock signal
8a	Shift register
7a	Data latch circuit
42	Gate
41	Shift register
5	Pulse signal generation circuit
1a	LED array

Fig. 2

13a	Latch
16a	Register

Fig. 3

#1	n Pulses